PHOTOCONTROL DEVICES HAVING FLEXIBLE MOUNTED PHOTOSENSORS AND METHODS OF CALIBRATING THE SAME

BACKGROUND OF THE INVENTION

The present invention relates to control devices and, more particularly, to photocontrol devices and methods of calibrating the same.

Photocontrol devices are used in a variety of applications where it is desirable to provide a control signal responsive to detection of a light level. One common application of such photocontrol devices is in the detection of ambient light levels. In particular, to detect that transition from daylight to night so that lights may be turned on for security, safety and/or aesthetic reasons. For example, street lights are generally provided with photocontrol devices to turn on the street lights at dusk. An example of such a photocontrol device is the Model 2000 series of photocontrols available from Tyco Electronics Corporation.

Because of the variability typically found in sensing devices such as photocontrol devices, they are generally calibrated before and/or after installation. Such calibration typically includes adjusting the sensitivity of a photosensor circuit included in the photocontrol device so that it activates a switch at a desired light level. The switch may be, for example, a relay in the photocontrol device that provides power to turn on a light when the detected light level drops below a selected level. Known approaches to adjusting the sensitivity of the photocontrol device to calibrate the photocontrol device include changing a calibration resistor coupled to the photosensor, providing a rotary mounted photosensor and/or changing the size of an aperture/window of the photocontrol device through which the photosensor receives light. Each of these approaches may increase the cost of the photosensor device and/or the difficulty of the calibration process.

SUMMARY OF THE INVENTION

Embodiments of the present invention provide methods for calibrating a photocontrol device having at least one flexible mounting leg mounting a photosensor

to a circuit board and being electrically coupled to activate a switching device and calibrated photocontrol devices. A photocontrol device is positioned proximate a light source. An aperture is positioned between the photosensor and the light source and an angle between the at least one flexible mounting leg and the circuit board is adjusted to calibrate a sensitivity of the photocontrol device to light from the light source passing through the aperture.

In other embodiments of the present invention, adjusting an angle includes bending the at least one flexible mounting leg. The at least one flexible mounting leg may be a first and second wire lead coupling the photosensor to a relay circuit of the photocontrol device. The first and second wire lead may be copper.

In further embodiments of the present invention, adjusting an angle includes adjusting a magnitude of misalignment between the photosensor and the aperture to calibrate the sensitivity of the photocontrol device. The magnitude of misalignment may be increased to decrease the sensitivity of the photocontrol device.

In other embodiments of the present invention, the photocontrol device is configured for mounting with the photosensor on an upper surface of the circuit board. A cover is positioned over the upper surface of the circuit board and the cover includes a light transmissive window therein defining the aperture. The magnitude of misalignment is adjusted by bending the at least one flexible mounting leg to increase an angle between the photosensor and the circuit board facing the aperture to reduce the sensitivity of the photocontrol device.

In further embodiments of the present invention, the cover includes a tool access opening on a top thereof. Positioning an aperture between the photosensor and the light source includes placing the cover over the upper surface of the circuit board. The magnitude of misalignment is adjusted by inserting an adjusting tool in the opening to contact the photosensor and moving the photosensor with the adjusting tool until a desired sensitivity is obtained. The light level of the light source may also be adjusted to a calibration level and the photosensor may be moved until a relay coupled to the photosensor changes state.

In other embodiments of the present invention, methods for calibrating a photocontrol device including a photosensor positioned to receive light from an aperture are provided. A flexible mounting leg of the photosensor is bent to a selected misalignment relative to the aperture to provide a desired sensitivity of the photocontrol device to light from the aperture.

In further embodiments of the present invention, calibrated photocontrol devices include a circuit board having a photosensor mounted on an upper surface thereof. A cover having a light transmissive window therein is positioned over the upper surface of the circuit board with the light transmissive window positioned adjacent the photosensor. The photosensor is mounted on the circuit board by at least one flexible mounting leg that is bent to a selected angle to misalign the photosensor and the light transmissive window to provide a desired sensitivity to light of the photocontrol device.

In other embodiments of the present invention, a detection circuit is coupled to the photosensor by the at least one flexible mounting leg and the detection circuit electrically couples the photosensor to a detection element of the detection circuit without a calibration resistor therebetween. The detection element may be a comparator. The photosensor may be misaligned toward an upper surface of the cover and away from the circuit board and the cover may be configured to present a shadowed region to the photosensor when the photocontrol device is positioned in sunlight.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an exploded perspective view of a photocontrol device according to some embodiments of the present invention;

Figures 2A-2B are perspective views illustrating calibration of the photocontrol device of **Figure 1** according to some embodiments of the present invention; and

Figure 3 is a flowchart illustrating operations for calibrating a photocontrol device according to some embodiments of the present invention.

DETAILED DESCRIPTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which illustrative embodiments of the invention are shown. In the drawings, the relative sizes of regions or features may be exaggerated for clarity. In the drawings, when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another

element, there are no intervening elements present. Like reference numerals refer to like elements throughout. This invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

Embodiments of the present invention will now be described with reference to the various embodiments illustrated in **Figures 1** to **3**. **Figure 1** is an exploded perspective view of a photocontrol device **100** according to some embodiments of the present invention. As shown in the embodiments of **Figure 1**, the photocontrol device **100** includes a base **105** and a mating cover **110** that together define an enclosure for a circuit board **115**.

The circuit board **115**, as illustrated in **Figure 1**, is connected to the base **105** by mounting screws **120**. The circuit board **115** also includes, on an upper surface **117** thereof, a photosensor **125** coupled to the upper surface **117** of the circuit board **115** by two flexible mounting legs **130**. While shown with two mounting legs **130**, it will be understood that more or less flexible mounting legs may be provided according to various embodiments of the present invention. In the illustrated embodiment of **Figure 1**, the flexible mounting legs **130** may be first and second wire leads that also electrically couple the photosensor **125** to a detection circuit of the photocontrol device **100**, generally illustrated by the various other electrical components shown on the circuit board **115**, and to the switching device **135**. The switching device **135** is illustrated as a relay in **Figure 1**. The photocontrol device circuitry of **Figure 1** is configured so that the detection of light by the photosensor **125** activates or deactivates the relay **135**. The relay **135** may, in turn, be coupled through the electrical connector **150** to an associated light source that may be turned on or off responsive to the state of the relay **135**.

As further shown in **Figure 1**, the cover **110** includes a light transmissive aperture (opening) or window **140** that allows ambient light to reach the photosensor **125**. The light transmissive window **140** is positioned adjacent the photosensor **125** when the cover **110** is positioned over the upper surface **117** of the circuit board **115** on the base **105**. The flexible mounting legs **130** are bent to a selected angle to misalign the photosensor **125** and the light transmissive window **140** to provide a desired sensitivity to light of the photocontrol device **100**.

It will be understood by those of skill in the art that various conventional detection elements may be used to couple the photosensor **125** to the relay **135**. For example, a comparator may be provided as a detection element in the detection circuit. The comparator may be an analog comparator having a reference voltage and/or may be a digital circuit having a programmable reference level.

Also shown in the cover **110** of **Figure 1** is a tool access opening **145** on a top or upper wall thereof. As will be described further herein, the tool access opening **145** may be used in adjusting the sensitivity of the photocontrol device **100** in accordance with various embodiments of the present invention. However, it will also be understood that the opening **145** may not be provided in the photocontrol device **100** as sold and may merely be provided as part of a test fixture used during calibration of the photocontrol device **100**. Alternatively, the opening **145** may be covered or otherwised closed before shipping of the photocontrol device **100**.

It will be understood that the alignment or more particularly, the misalignment, of the photosensor **125**, as that term is used herein, refers to the alignment of the sensing surface or eye **127** of the photosensor **125** relative to the light transmissive window **140** or other aperture that may be provided for use with calibration methods as will be described for various embodiments of the present invention herein. Photosensors and related detection circuits and relays suitable for use with the present invention, such as photosensors including copper component mounting leads are known to those of skill in the art and will not be described further herein.

Operations related to calibration of a photocontrol device according to various embodiments of the present invention will now be further described with reference to the calibration/test apparatus schematically illustrated in **Figures 2A** and **2B**. As shown in **Figures 2A** and **2B**, the photocontrol device **100** is positioned proximate a light source **205**. A pair of light diffusion plates **215, 215'** are positioned between the light source **205** and the photocontrol device **100**. The light diffusion plates **215, 215'** are shown as mounted in a parallel relationship by mounting brackets **220**. The light transmissive window **140** is shown positioned between the photosensor **125** and the light source **205** to define an aperture between the light source **205** and the photosensor **125**.

The light source **205** is coupled to a light level control circuit **210** and the photocontrol device **100** is coupled to a photocontrol device control/detection circuit

225. A user input/output circuit **230** as operatively connected to the light level control circuit **210** and photocontrol device control/detection circuit **225**. The user input/output circuit **230** is operative to send signals to the light level control circuit **210** to adjust the light level of the light source **205** to a desired calibration level for use in calibrating the photocontrol device **100**. The user input/output circuit **230** is further configured to provide inputs to the photocontrol device control/detection circuit setting reference voltage levels and the like for establishing a switching level for the relay **135** and further to detect activation or deactivation of the relay **135**.

Figures 2A and **2B** illustrate embodiments of the present invention in which an adjusting tool, such as the screw driver **235**, is used to move the photosensor **125** to provide a desired sensitivity for the photocontrol device **100**. As shown in **Figure 2A**, the photosensor **125** extends generally transversely from the upper surface **117** of the circuit board **115** with the legs **130** and the photosensor **125** running in a plane generally parallel to a plane defined by the light transmissive window **140** and substantially in alignment with the window **140**. As shown in **Figure 2B**, the legs **130** have been bent, by moving the screwdriver **235** in the opening **145**, to a misalignment angle of approximately 30°. In particular, in **Figure 2B,** the photosensor **125** is misaligned toward an upper surface of the cover **110** and away from the circuit board **115**. In other words, the eye **127** is pointed away from the upper surface **117** of the circuit board **115**. Such a direction of misalignment may be desirable where the cover **110** is configured to present a shadowed region to the photosensor **125** when the photocontrol device **100** is positioned in sunlight. Such an adjustment orientation towards an upper surface of the cover **110** may provide more uniform detection of light levels in use by reducing the potential for variability in reflection effects from the circuit board **115** and/or ground cover in the area where the photocontrol device **100** is mounted in use causing variability in the switching characteristics of a control device **100**.

It will be understood that a variety of different light sources, including light emitting diodes and the like, may be used as the light source **205**. It will further be understood that a light diffusion plate **215**, **215'** are merely illustrative of one approach to providing controlled lighting for test purposes and other approaches may be used in various embodiments of the present invention. Furthermore, both **Figures 2A** and **2B** illustrate using the light transmissive window **140** in the cover **110** as the aperture between the light source **205** and the photosensor **125**. It will be understood

that any suitable test aperture positioned between the photosensor **125** and the light source **205** may be used in various embodiments of the present invention.

Operations for calibrating a photocontrol device according to various embodiments of the present invention will now be described with reference to the flowchart illustration of **Figure 3**. The present invention provides methods for calibrating a photocontrol device including a photosensor positioned to receive light from an aperture by bending a flexible mounting leg of the photosensor to a selected misalignment relative to the aperture to provide a desired sensitivity of the photocontrol device to light from the aperture.

For embodiments of the present invention as illustrated in **Figure 3**, operations begin at **Block 305** by positioning the photocontrol device **100** proximate a light source **205**. An aperture, such as the light transmissive window **140**, is positioned between the photosensor **125** and the light source **205 (Block 310)**.

In some embodiments of the present invention the light source **205** may have its light level adjusted, for example, using the light level control circuit **210**, to a calibration level for testing. The photocontrol device control/detector circuit **225** may also adjust reference voltages and the like for the photocontrol device **100** to set test conditions for use during calibration at **Block 315**. An angle between the mounting leg(s) **130** of the photosensor **125** and the circuit board **115** is adjusted to calibrate a sensitivity of the photocontrol device **100** to light from the light source **205** passing through the aperture **140 (Block 320)**. Adjustment operations continue until a desired sensitivity is obtained **(Block 325)**.

As discussed with reference to **Figures 2A** and **2B**, operations at **Block 320** may provide adjusting a magnitude of misalignment between the photosensor **125** and the aperture **140** by inserting an adjusting tool **235** in opening **145** to contact the photosensor **125** and moving the photosensor **125** with the adjusting tool **235** until a desired sensitivity is obtained. The detection of the desired sensitivity has been reached may be provided by moving the photosensor **125** until a relay **130** coupled to the photosensor changes state as detected through the photocontrol device control/detection circuit **225** and the user input/output circuit **230**.

As described with reference to various embodiments of the present invention above, bending flexible mounting members such as wire leads of a photosensor to provide a desired sensitivity to the photocontrol device may eliminate the need for sliding shutters, variable resistors and the like associated with known methods of

calibrating photocontrol devices. In particular embodiments where the photosensor is mounted by the wire leads already provided conventionally with certain photosensor devices, there may be no need for any additional components or materials as the wire leads are already in use and required for mounting such photosensors so no additional costs or change from a conventional photosensor of such type may be required. Benefits may be provided both from elimination of costly components, such as sliding shutters or variable resistors, and may further provide benefits by reducing the need for maintaining inventory, such as inventory required to provide a range of varied calibration resistors, soldering posts for mounting such resistors in the photocontrol device, and may also eliminate operations, such as a welding operation used to mount selected calibration resistors used for adjusting photosensitivity in various conventional approaches. In some embodiments of the present invention, the resulting light calibration may also provide improved control over sensitivity.

The flowchart of **Figure 3** illustrates the architecture, functionality, and operation of possible implementations of methods for calibrating a photocontrol device according to some embodiments of the present invention. It should be noted that, in some alternative implementations, the acts noted in the blocks may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may be executed in the reverse order, depending upon the functionality involved.

The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Therefore, it is to be understood that the foregoing is illustrative of the present invention and is not to be construed as limited to the specific embodiments disclosed, and that modifications to the disclosed embodiments, as well as other embodiments, are intended to be included within the scope of the appended claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.